US Army Corps
of Engineers

Hydrologic Engineering Center

FY2000 Annual Report

U.S. Army Corps of Engineers
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Hydrologic Engineering Center
FY2000 ANNUAL REPORT

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DIRECTORS COMMENTS

Top priorities for FY2000 were our Corps Water Management System modernization software development and integration project, NexGen software research and development project, watershed and water resource system analysis, and comprehensive system studies. Progress was substantial in all these areas. Customer demand for HEC services and products continues to be high. Our reimbursable projects program continues strong, resulting in another fiscal high at year-end. Many of the senior professional staff are reaching retirement age and retirements have commenced. The pace will quicken in FY2001 on through 2002. Restocking of staff has begun in earnest.

The project to modernize the Water Control Data System (WCDS) software began in FY1997. Because the modernized system will be much more than a data system, it was renamed to the Corps Water Management System (CWMS). The CWMS is the decision support Automated Information Systems (AIS) that supports the Corps water management mission. It embodies data acquisition, validation, transformation and management; forecasting, simulation and decision support analysis; and information dissemination. Modernizing and deploying the corporate software for CWMS is a six-year, $7.6 million centrally PRIP funded, Corps AIS improvement project managed under the Corps Life Cycle Management of Information Systems (LCMIS) process. The management structure and design teams form a unique arrangement for providing oversight and field participation in the enterprise-wide development and integration project. The significant accomplishment in FY2000 was installation of Test Version 2.0 at four field sites. This is the second planned interim test installations prior to Test 3.0/CWMS Version 1.0, which will complete the system. CWMS is scheduled to be deployed Corps-wide in 2001/2002. The project is on schedule and within budget. Project documents are available on the project Internet Web site: (http://cw71.cw-wc.usace.army.mil/cwcinfo/cwc.html).

The NexGen software research and development project continues to roll out products for Corps field offices. There are now Arc/Info and ArcView version of HEC-GeoRAS, providing GIS utility support for HEC-RAS, the widely popular river hydraulics software package. HEC-HMS (Version 2.0) was also released. This new version of the Corps standard watershed model includes a moisture accounting loss algorithm. Work is now underway on the next version that will add dam safety and planning analysis capabilities. A pre-release of the unsteady flow version of HEC-RAS (Version 3.0) was released for testing. Public release is expected early next fiscal year. A GIS utility package (HEC-GeoHMS) was released in the summer. This utility provides substantial capability to effectively use national terrain data sets to rapidly develop HEC-HMS models. Building models for the tributaries to the Central Valley of California was the shakedown application of GeoHMS. The major flood damage and risk analysis software package, HEC-FDA, continues to be improved. The two new NexGen software programs that are components of CWMS were improved and are included in CWMS Test Version 2.0. They are a new simulation/real-time reservoir operations model, and a flood impact analysis model. These programs will continue to be improved and will likely be released within the Corps in stand-alone form late in calendar year 2001.

One aspect of our activities in the risk-based analysis and flood frequency analysis areas was completed this past year. The panel of The National Academy of Sciences, National Research Council (NRC) that reviewed the Corps use of risk-based analysis delivered its final report this year. The Hydrologic Engineering Center represented the Corps attending meetings, making presentations, and exchanging information on this topic. The report focused substantially on the HEC-FDA program that provides the analytical tool for implementing risk analysis in the field. In general, the NRC report commends the Corps for their risk analysis initiative, and encourages

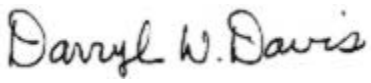
continued development of the methodology. Suggestions for improvements are made in several areas. We began a research project to address hydrologic risk and uncertainty and environment restoration performance. This is an area of inquiry that is expected to grow. The re-study of flood frequency on the upper Mississippi River in light of the flood of 1993 continues to close in on the final phase. A report documenting the flow frequency analysis methods and preliminary results was completed. A case example application of extreme flood magnitude and frequency estimates was initiated as part of the new Dam Safety R&D. Preliminary results are expected in FY2001.

Six PROSPECT courses were conducted for a total of six weeks of training. The courses covered several hydrologic engineering and planning analysis topics including HEC-RAS, HEC-HMS, GIS applications, and two new watershed/river and wetlands restoration courses. Attendance averaged about 25 students per course. Five on-site workshops were also held totaling four weeks of sessions for 150 students. While this continued the recent trend of reduced PROSPECT sign-ups and increased requests for on-site workshops, FY2001 looks to reverse the trend with up to ten PROSPECT courses likely to be presented. Topics presented in the workshops included HEC-RAS, HEC-HMS, and hydrologic engineering in planning.

Reimbursable project work was undertaken for 14 Corps field offices as well as HQUSACE, the Federal Emergency Management Agency, University of California, and the National Institute for Building Sciences. Projects include watershed and reservoir system modeling, water quality, risk analysis, river hydraulics, wetlands hydrology, water control management, regional statistical analysis, flood damage analysis, GIS applications in hydrology and hydraulics, and groundwater modeling. In the upper Mississippi, the Hydrologic Engineering Center is managing the project to update the model geometry for the Mississippi Basin Model System (MBMS) to reflect more recent mapping and to develop an inundation mapping component based on the new mapping. This project was re-activated this year. Map products from the contractors continue to lag, resulting in a one-for-one lag in the project, with late delivery of up to 18 months likely. Remaining work includes cutting the new river section geometry, integrating these new digital map-based geometry sections into the UNET models, re-calibrate the models, and prepare final reports. It is clear that the Corps will not receive contractor map products in time to complete the project in FY2000. Work will need to continue through FY2001 before completion can be declared. The reimbursable project to assist in modeling the Sacramento and San Joaquin river basins for flood control operations is moving toward the documentation phase. This is part of a comprehensive study by the Sacramento District to review the flood damage reduction system for the Central Valley of California. Preliminary models were completed in Phase I, and improved models are now near completion under Phase II. The models (separate models for the Sacramento Valley and San Joaquin Valley) are: HEC-5 for flood control operations; HEC-ResFloodOpt, system flood control operation optimization; HEC-FIA, flood economic/damage impact analysis model, and HEC-HMS (flood runoff model). Data compilation, and some of model development will later serve as the base for modernized CWMS implementation for these areas. We began an interesting project that is developing a flood forecast system for an area of the Susquehanna basin that has as its final outputs, forecast flood inundation map with associated flood damage, a first. Work will continue through this year into spring FY2001. The total reimbursable project program was over $2 million with individual projects ranging from a few thousand dollars to near a million.

The Hydrologic Engineering Center's program for FY2001 will continue FY2000 efforts at the brisk pace reflected at the end of the year. We will continue fielding new versions of the NexGen software packages HEC-RAS, HEC-HMS, and HEC-FDA, and companion GIS utility software. Also emerging will be the first public release of the new reservoir simulation program HEC-ResSim, and initial unsteady flow capability of HEC-RAS (Version 3.0). Test Version 3.0 of the modernized CWMS will be installed and tested in five Corps offices, a favorable LCMIS

Milestone Decision III secured, and Corps-wide deployment commence. PROSPECT training will increase to about ten courses and the number of field workshops will likely continue at about the same rate. Research and Development funding is expected to continue to decline - not a good trend, software maintenance and support and WCDS modernization funding will remain at about FY2000 levels, and reimbursable technical assistance and special projects will likely level off. On balance, the result is expected to be a stable to slight increase in funding over that of FY2000. The reorganization of HQUSACE is complete, with the Hydrologic Engineering Center reassigned as a Center within the Institute for Water Resources. We expect increased synergy with other IWR elements, and anticipate no adverse affect on services to our customers.



Darryl W. Davis, P.E.
Director

ADMINISTRATION

Responsibilities

The Hydrologic Engineering Center (HEC) was established in 1964 to provide applied research, training, and technical assistance in hydrologic engineering to Corps field offices. In 1971, responsibilities were expanded to include planning analysis. Current activities now address a wide range of hydrologic engineering and planning analysis concerns.

The annual program is based on: (1) program direction from the HQUSACE Civil Works Directorate; (2) approved research and development program; (3) requests for assistance from Corps district and division offices; (4) cooperative work with Corps research laboratories; and (5) cooperative work with other government and professional organizations. Program activities are coordinated on a continuing basis with HQUSACE proponents and the Corps' user community.

Goals of the Hydrologic Engineering Center

The primary goal of the Hydrologic Engineering Center is to support the Corps in its water resources management responsibilities. This is accomplished by increasing the Corps technical capability in hydrologic engineering and water resources planning and management and providing leadership in improving the state-of-the-art in hydrologic engineering and water resources planning.

By means of programs in research, training, and technical assistance, the Hydrologic Engineering Center maintains awareness of the problems and needs of the Corps and the nation. A commitment is also made to keep abreast of the latest developments throughout the profession, and to make use of this information in a manner best suited to the needs of the Corps.

The Hydrologic Engineering Center increases the effectiveness of the Corps and the profession by bridging the gap between the academic community, practicing hydrologic engineers, and planning professionals. Research and training activities that can be best accomplished by universities are not undertaken. The Hydrologic Engineering Center incorporates state-of-the-art procedures and techniques into manuals and comprehensive computer programs. The resulting products are made available to the Corps, and to other United States and international professionals through an effective technology transfer system of technical assistance, publications, videotapes, and training courses.

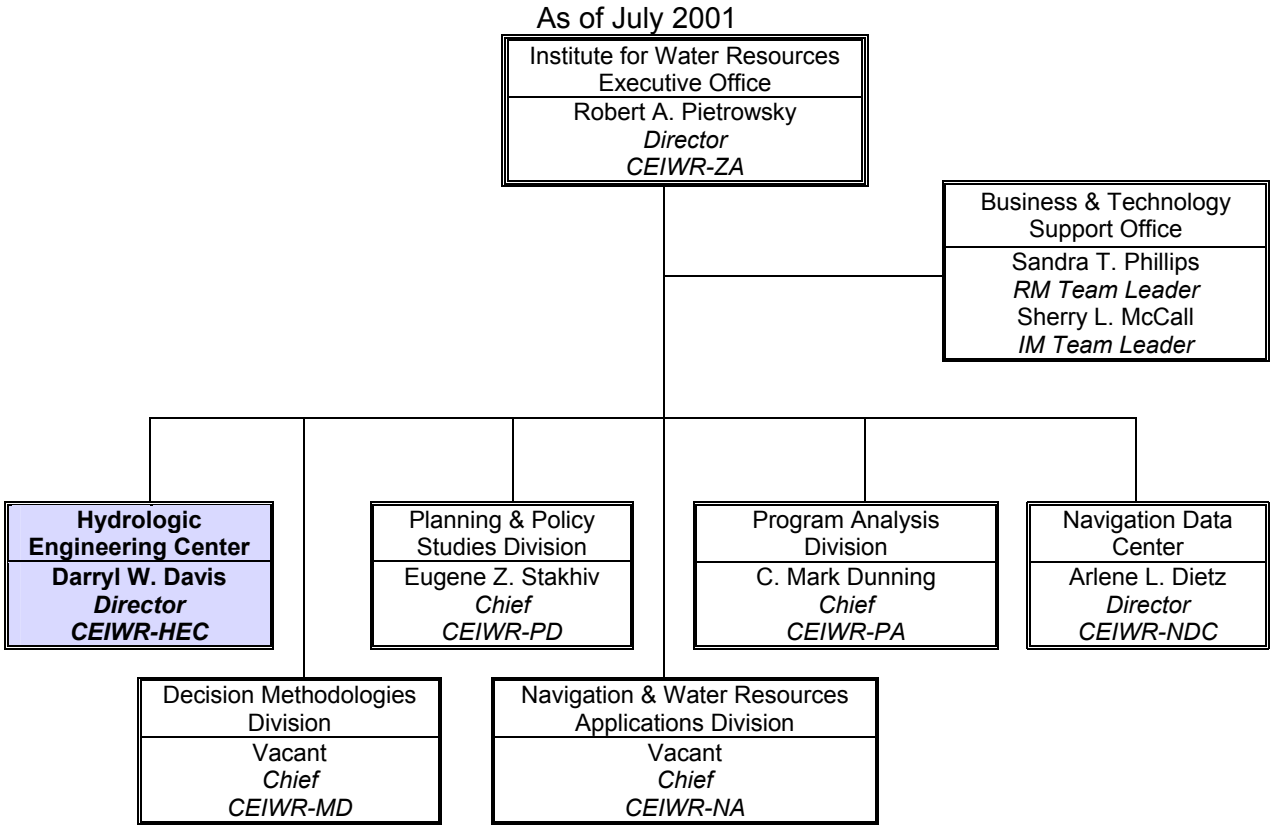
Research supplements relevant research at universities, private industry and other agencies. It develops systematic procedures that produce a quality product; it also saves time for experienced specialists and enables less-experienced personnel to use procedures effectively.

Training develops the Corps workforce and reduces the time necessary for young engineers and planning professionals to become proficient in technical analysis. It also familiarizes more experienced professionals with new methods.

Technical assistance provides advice and assistance to Corps field personnel in the application of new or unfamiliar procedures to solve complex, precedent-setting water resources problems.

Organization

The Hydrologic Engineering Center is an element of the Institute for Water Resources (IWR) headquartered in Alexandria, Virginia. The U.S. Army Corps of Engineers Institute for Water Resources was formed to provide policy and program analysis and to perform forward-looking analysis and research in developing planning methodologies for the Civil Works program. Since its beginnings in 1969, the Institute provides the Civil Works program with a variety of products to enhance the Corps of Engineers water resources development planning.



The Hydrologic Engineering Center's permanent staff is organized into four functional units reflecting major focus areas.

The Executive Office provides the guidance, policy, management and administrative support for the Center. Local support is received by contract from the Sacramento District, and human resources services from the South Pacific Division. Finance and accounting and management support is provided by the Institute for Water Resources headquarters.

The Hydrology and Hydraulics Technology (H&H) Division administers the applied research program to develop systematic procedures for field application. Technical and functional responsibilities of the H&H Division are: research program administration; surface and groundwater hydrology; river hydraulics and surface erosion/sediment transport; and hydrologic statistics.

The Water Resource Systems (WRS) Division manages the training and tech-transfer activities of the Center and develops and integrates analytical methods for water resource planning activities. Technical and functional responsibilities of the WRS Division are: training program administration; reservoir systems; water resource systems optimization; flood damage analysis; risked-based analysis; river/ecosystem restoration; and, watershed studies.

The Water Management Systems (WMS) Division provides support for technical studies and water control management. Technical and functional responsibilities of the WMS Division are: water control management technology; data acquisition, communications and management; Corps Water Management System (CWMS) models applications and support; hydrology and hydraulics forecasting; reservoir regulation; the Hydrologic Engineering Center's software engineering/integration standards and practices; and, IT management and administration.

Permanent Employees

As of July 2001

Executive	
Darryl W. Davis	**Director**
Adela C. Pucci	Executive Secretary (OA)
Diane A. Cuming	Administrative Officer
Hydrology and Hydraulics Technology (H&H) Division	
Arlen D. Feldman	**Chief**
Doug Foster	Secretary (OA)
Lisa Pray	Computer Specialist
James Doan	Hydraulic Engineer
Jon Fenske	Hydraulic Engineer
Christopher Goodell	Hydraulic Engineer
Mark Jensen	Hydraulic Engineer
William Scharffenberg	Hydraulic Engineer
D. Michael Gee	Senior Hydraulic Engineer
Gary Brunner	Senior Technical Specialist (River Hydraulics)
Water Resource Systems (WRS) Division	
Christopher N. Dunn	**Chief**
Josie Garcia	Secretary (OA)
Eileen Haramoto	Training Assistant
Penni Baker	Computer Specialist
Marilyn Hurst	Computer Specialist
Cameron Ackerman	Hydraulic Engineer
Beth Faber	Hydraulic Engineer
John Hickey	Hydraulic Engineer
Robert Carl	Senior Hydraulic Engineer
David Goldman	Senior Technical Specialist (Hydrologic Statistics)
Water Management Systems (WMS) Division	
Daniel J. Barcellos	**Chief**
Jeff Houghten	Computer Specialist
Carl Franke	Hydraulic Engineer
Joan Klipsch	Hydraulic Engineer
William Charley	Senior Hydraulic Engineer
Thomas Evans	Senior Hydraulic Engineer
Matthew McPherson	Senior Hydraulic Engineer
Alfredo Montalvo	Senior Hydraulic Engineer
Arthur Pabst	Senior Technical Specialist (Water Control Mgmt)

Facilities

The Center is located in Davis, California, near the University of California, Davis campus. Facilities include office space for the staff and visitors, a classroom with a capacity for 30 students, a library, a publications storage center, and computer equipment. The computer hardware consists of personal computers, several SUN engineering workstations and a variety of supporting video, graphics and printing equipment.

Funding

Funding is received from several sources: the Civil Works R&D program, special projects, the Corps-sponsored training program, field office subscriptions for computer software support, PRIP funding for development and deployment of the Corps Water Management System, and reimbursable assistance. Reimbursable assistance includes work for Corps district and division offices; research and development laboratories; sister organizations of the Institute for Water Resources; HQUSACE Planning and Policy Division, Civil Works Directorate, and other government agencies.

The Hydrologic Engineering Center's budget for FY2000 totaled $6.1 million with about 25% each from Civil Works Research and Development program, the Corps Water Management System (CWMS) modernization and reimbursable technical assistance. The remaining 25% was divided among training, software support and the Mississippi Basin Modeling project.

RESEARCH AND DEVELOPMENT

Corps field-office needs are the basis for the Hydrologic Engineering Center's research program. Corps headquarters and other Federal agencies also identify new research needs. Most of the research effort is technique-oriented and emphasizes a generalized solution to specific field problems. Research results are transferred to the field through training and technical assistance projects and through manuals, regulations, and computer software.

Planning, design, construction, and operation and maintenance of today's multiple-purpose water projects require complex interdisciplinary analyses. These complex problems present major methodological and computational tasks to water resources professionals. Research seeks solutions to these problems through development of systematic methods and the use of advanced analysis techniques.

Research was conducted in 15 work units as described in the following paragraphs. These work units represent specific technical needs identified in the Corps R&D program. Work done was under the area of:

- Hydrologic Engineering Research Program
- Risk Analysis of Water Resource Investments
- Geographic Information Systems
- Risk Analysis for Dam Safety

Hydrologic Engineering Research Program

The main focus of this research program is the development of the next generation (NexGen) of hydrologic engineering software. The NexGen program packages are planned as successors to the widely used existing Hydrologic Engineering Center's programs. The software includes many new and updated engineering algorithms and is designed for the interactive, desktop computer environment with graphic user interfaces. Much emphasis has been placed on the engineer-computer interface to enhance the computational power for engineering analyses. The software has a common, distinctive look and feel, uses common software libraries where possible, and is modular among user interface, graphical and database support, and analytical components. The NexGen work is progressing very well; several versions of the river hydraulics, watershed hydrology, and flood damage systems have been released, and the reservoir system simulation work became active.

FY2000 Work Units

- River Analysis System
- 1D Unsteady Modeling for River Analysis
- Catchment Analysis System
- Flood Damage Analysis Package
- Reservoir Analysis System
- Terrain-based H&H Modeling
- Urban Hydrology and Hydraulics Methods/Models
- Integration of the Hydrologic Engineering Center's NexGen Software for Watershed Studies
- Flood Hydrology and Hydraulics of Wetlands
- Resolving Water Allocation and Use Conflicts
- Improved Streamflow Estimation and Project-Aquifer Impact Analysis

New Work Units for FY2001

- Flood Impact Analysis
- Advanced Geospatial H&H Analysis
- Environmental Quality Enhancements for Catchment Analysis
- Reservoir System Flood Optimization

FY2000 Work Units

River Analysis System

This work will produce a consistent set of one-dimensional river analysis software tools for use by H&H engineers in workstation and PC environments. A single geometric representation of the river and floodplain will be used for all simulations; the initial version will be for steady flow and later versions will add unsteady flow and sediment transport. This work unit addresses only the steady flow capabilities. Version 1.0 of the River Analysis System (HEC-RAS) software and documentation was released in FY1995. Version 2.0 was released in FY1997 and included several improvements for flow through bridges and graphical editing of cross sections. In FY1998, Version 2.2 was released which included new features for floating debris on bridge piers; new bridge design editor; graphical cross-section editor; and several new output variables. Much improved bridge and culvert hydraulics were included. The final steady-flow software features for split flow optimization and bridge skew were completed in FY1999. An initial test version of the unsteady flow module in HEC-RAS was also developed.

Accomplishments and Outlook

In FY2000, the final steady-flow HEC-RAS capability was released including updated User's, Hydraulic-Reference, and Applications-Guide manuals. This FY concludes development of the main steady-flow capabilities for HEC-RAS; a new work unit for 1D Unsteady Modeling for River Analysis was begun.

1D Unsteady Modeling for River Analysis

A comprehensive unsteady-flow analysis methodology will be developed in the River Analysis System, HEC-RAS. The package will be designed and developed to meet one-dimensional steady state and unsteady-flow river hydraulic analysis needs for floods and low flows. Separate modules for sediment scour, transport, and deposition capabilities will also be developed in a future work unit. The HEC-RAS river analysis system capabilities are all based on a single geometric representation of the river and floodplain.

Accomplishments and Outlook

In FY2000, HEC-RAS work concentrated on the development of the unsteady flow module. The unsteady flow capability now provides the basic computational elements for the unsteady flow program, but not all the hydraulic structures features of the full UNET program. A beta version (of HEC-RAS 3.0) was released and several updates to the software made based on that field testing. In FY2001, Version 3.0 will be released with updated User's, Hydraulic Reference, and Applications-Guide manuals. New features will be added to the initial HEC-RAS unsteady-flow capability in response to field needs.

Catchment Analysis System

This work unit is developing methodologies and numerical models for both continuous and event-oriented simulation of complex flood and low-flow river basin hydrologic processes for the NexGen Hydrologic Modeling System (HEC-HMS). The simulation capabilities developed here will be applicable to planning, design, and real-time water control. The analysis system will be

built of modular components with a catchment model as the central component. The modular, object-oriented design will facilitate inclusion of special methods for interaction with river hydraulics, interior area flood analysis, urban runoff, groundwater connections, GIS, etc. A graphic user interface, GUI, will maximize the engineer's ability to prepare, understand, and display data and results. HEC-HMS Version 1.0 was released in FY1998. Snowmelt simulation capabilities were initially added in a stand-alone program under a contract with CECRL. In FY1999, an updated version, 1.1, was released with the new Technical Reference and an updated User's Manual. Version 2.0 with continuous soil moisture accounting simulation capabilities and a complementary, separate, snow simulation program were Beta tested.

Accomplishments and Outlook

In FY2000, Version 2.0 of HEC-HMS was released with updated Technical-Reference and User's Manuals. Design efforts continued for three new computational-engine capabilities: improved reservoir modeling, snowmelt, and frequency curve generation. The reservoir model will be expanded to allow the user to specify spillway and outlet structures and dam-break criteria. The separate snow processes model development and applications testing continued at CECRL. A new design for the HMS graphic user interface was completed and reviewed at an in-house seminar. In FY2001, Version 2.1 will be released which includes computational-engine enhancements for new hypothetical frequency-based storms, SCS storms, and paired-data usage including dimensionless unit graphs.

Flood Damage Analysis Package

This work unit is developing a next generation of analysis methods and software for flood damage computations. The goal is to enhance the Corps' capability to develop structure inventory information, and to estimate the effects of various project works on flood damage reduction. The next generation Flood Damage Analysis (HEC-FDA) computer program replaces the old FDA package that included the Structure Inventory of Damage (HEC-SID), and Expected Annual Damage (HEC-EAD) programs. Version 1.0 of HEC-FDA was released in FY1998. Several enhancements were made to the flood damage computation routines, output reports, and user interface. This work was closely integrated with the Statistical Methods in Hydrology work unit and another work unit in the Risk Analysis R&D Program to ensure appropriate new risk and uncertainty methods were developed and incorporated. In FY1999, an Applications Manual was drafted and the HEC-FDA software was updated.

Accomplishments and Outlook

In FY2000, technical capabilities were expanded, and design and coding for incorporating a new user interface consistent with NexGen HEC-HMS, HEC-RAS, and GIS capabilities were completed. This year concludes the initial development of HEC-FDA; in FY2001, a new work unit on flood impact analysis will start. The new work unit will expand the flood analysis capabilities to other environmental features not necessarily represented well by traditional damage computations.

Reservoir Analysis Systems

This work unit is developing a family of reservoir analysis tools to facilitate investigations ranging from reconnaissance-level planning studies to detailed reservoir regulation plan investigations. The family of programs will include the existing HEC-5 for multi-purpose simulation, a reservoir optimization capability, a systems analysis-based reservoir system evaluation methodology for large-scale screening studies, and modular reservoir regulation routines. These reservoir regulation routines can be implemented in real-time analysis for complex flood and low-flow conditions. Field needs were surveyed and major requirements defined. The Prescriptive Reservoir Model (HEC-PRM) was designed, developed, tested, and

released; it is a systems analysis model for evaluation/screening of multi-purpose, multi-reservoir systems. In FY1997, a multipurpose reservoir model graphic user interface was developed. In FY1998, a new operation algorithm was developed and incorporated in a prototype reservoir model and GUI. In FY1999, the Beta HEC-ResSim reservoir model and a draft user's guide were developed to meet Version 1 water control requirements.

Accomplishments and Outlook

In FY2000, the Corps' needs for reservoir system modeling were re-assessed and the Hydrologic Engineering Center's software revised such that there is a single reservoir modeling framework, HEC-Res that includes a simulation component (HEC-ResSim), a flood optimization component (ResFloodOpt), and a multi-purpose optimization model (ResPrm). A functional ResSim program, with limited detailed outlet and system capabilities, was completed. A fully functional version of ResSim will be completed in FY2001 in connection with the deployment of the Corps Water Management System Version 1.0.

Terrain-Based H&H Modeling

Existing hydrologic and hydraulics models do not adequately represent the spatial variation in meteorological processes and geographic characteristics. This work unit will develop spatially distributed hydrologic and hydraulic modeling capabilities that can use digital terrain, remote sensing, radar-measured rainfall, and GIS data effectively. Digital elevation data will be the primary source of topographic information with which to develop spatially distributed models. Spatial precipitation will be based on both gaged data and radar-sensed distributions. In FY1999, a GIS preprocessor for HMS, GeoHMS, was designed and built via a Cooperative Research and Development Agreement with the Environmental Systems Research Institute, Redlands, California. GeoHMS identifies and delineates watersheds and rivers, creates the structure for HEC-HMS and georeferences a standard hydrologic grid to the National Weather Service's (NWS) radar rainfall grid. Also in FY1999, an ArcInfo version of GeoRAS was released. GeoRAS integrates digital elevation data for floodplains and river channels, together with existing cross-sectional information, for use with the Corps standard river hydraulics model, HEC-RAS. The water surface profile computations results can then be plotted directly on that digital representation of the floodplain.

Accomplishments and Outlook

In FY2000, the Geospatial Hydrologic Modeling Extension to ArcView, HEC-GeoHMS, was released with extensive documentation. Also HEC-GeoRAS was improved and rewritten for the ArcView system and released with an updated user's manual. FY2001 developments will see expanded capabilities for both HEC-HMS and HEC-RAS with new program releases.

Urban Hydrology and Hydraulics Methods/Models

Methodologies and software algorithms will be developed for the specialized nature of urban hydrology and hydraulic studies. Existing tools in the profession will be used and/or adapted to meet Corps needs. Interconnection of modeling capabilities (e.g., HEC-HMS and UNET with EPA-SWMM) will be facilitated by implementing access to the Hydrologic Engineering Center's Data Storage System, HEC-DSS. Guidance and software will be provided for routing of flows through culverts, pipes, and the many man-made features of urban areas. A state-of-the-practice seminar was held to describe Corps capabilities and needs to leaders in the profession in FY1994. The seminar proceedings (published in FY1995) identified and summarized Corps needs and directions for improving urban hydrologic and hydraulic methods. The two primary needs were better interfaces between hydrologic and hydraulic models, and improved hydraulic simulation of storm sewer networks. In FY1995 and 1996, the UNET model was tested on storm sewer networks. In FY1997, software and guidance was provided to EPA-SWMM model

developers for incorporation of HEC-DSS linkages for input and output. In FY1998, kinematic wave routing for steep channels was added in HEC-HMS. In FY1999, improved urban hydrologic and hydraulic features were tested for HEC-HMS and HEC-RAS.

Accomplishments and Outlook

In FY2000, user guidance for analyzing different urban hydrologic and hydraulic flow situations were completed. Improvements for urban simulation capabilities were identified for HEC-HMS and HEC-RAS. An important part of that capability is more effective communication between the two programs. These new modeling techniques will be incorporated in the HEC-HMS, and HEC-RAS in their respective work units.

Integration of the Hydrologic Engineering Center's NexGen Software for Watershed Studies

This new work unit will create procedures and capabilities to provide a fully integrated suite of the Hydrologic Engineering Center's models for watershed and water resources management studies. The integration will make extensive use of the modernized Corps Water Management System (CWMS) to develop software links for data processing, modeling and spatially referenced displays. A watershed style Control and Visualization Interface (CAVI), tailored from the CWMS CAVI, will be designed as the umbrella interface integrating the suite of the Hydrologic Engineering Center's models. To ensure district shared-data capability, the watershed CAVI will also link to CWMS: database of watershed physical data, precipitation, streamflow, and model parameters; spatially referenced data maps and displays; and internet/web-sight links. The terminology, analysis procedures, and output will be consistent with requirements of ER 1105-2-100, ER 1105-2-101, EM 1110-2-1619, and other Corps guidance criteria. The final product will streamline the analytical process, while producing more consistent results, and shared displays.

Accomplishments and Outlook

In FY2000, the CAVI design was initiated and underwent user evaluation. Work began on development of a functional prototype to be tested in FY2002. The design of the software and user interface emphasize streamlining of the analysis process while producing more consistent results and shared displays among the several programs.

Flood Hydrology and Hydraulics of Wetlands

This work unit will characterize the hydrologic and hydraulic impacts of wetlands on individual areas and on regional floods. Analytical methods for determining the hydrologic and hydraulic impacts of wetlands (or loss thereof) on a regional basis will be developed, tested, and documented. The research will begin with: a review of pertinent literature; identification of completed and ongoing Corps wetlands delineation and impact studies; gathering of hydrologic, geographic and other information on available studies; and formulation and testing of indicators and methods for analysis of wetlands impacts. After establishing methods for analyzing individual areas, methods for regional wetlands impacts analysis on floods will be developed and tested. This work will be closely coordinated with the work unit on "Integration of the Hydrologic Engineering Center's NexGen Software for Watershed Studies."

Accomplishments and Outlook

Limited funding in FY2000 provided only for some literature review and participation in Corps meetings to define environmental modeling needs. The materials developed were presented in a Corps PROSPECT course. In FY2001, the history of drainage design in the wetland areas will be reviewed with the intent of learning how to properly represent the pre-development conditions. Methods for studying regional wetlands impacts will be investigated.

Resolving Water Allocation and Use Conflicts

The original objectives were to develop generalized water allocation, conflict resolution capabilities; these were modified based on the response of the field review group. Emphasis is now on analytical methods to assist in Corps studies for reservoir operations where conflicts exist. A framework for resolving water allocation and use conflicts using non-economic relative-cost penalties will continue to be developed, applied, and refined. Systems analysis techniques (linear programming and network analysis) and traditional simulation models will provide a means for identifying, understanding, and resolving conflicts. The Hydrologic Engineering Center's Prescriptive Reservoir Model (ResPrm) and Linear Programming for Flood Control Operations (ResFloodOpt) programs are key components under this work unit. In FY1996, improvements were made to HEC-ResPrm, and a seminar titled "Resolving Water Allocation and Use Conflicts" was held. The Flood Control Linear Program (HEC-ResFloodOpt) was developed to model reservoir flood control operations at a range of time intervals. HEC-ResPrm was tested for conflict resolution applicability in conjunction with other projects on the Bill Williams River and the South Florida Everglades; and HEC-ResFloodOpt was similarly tested on another project for the Iowa and Des Moines Rivers system. In FY1998, enhancements were made to HEC-ResFloodOpt to allow better representation of flood damage costs and the efficient solution of very large linear programs. In FY1999, field testing of the Beta version of Corps Flood Control Linear Program (HEC-ResFloodOpt) was performed and a draft user's manual prepared.

Accomplishments and Outlook

In FY2000 conflict resolution information will also be developed via post processing of the Hydrologic Engineering Center's reservoir system simulation model results. The Hydrologic Engineering Center's package of reservoir analysis tools was reorganized into simulation, flood control optimization, and multi-purpose optimization, HEC-ResSim, - ResFloodOpt, and – ResPrm, respectively. The work unit ends this FY and future developments will be will be made in work units specific needs of those models applications.

Improved Streamflow Estimation and Project-Aquifer Impact Analysis

This work will develop, document, and deploy a suite of analysis methods and computer routines to enable computation of the rate and volume of water exchange between the ground and the surface. The computations will be designed to make use of readily available information and be tailored to the needs for planning, design and operation of existing and potential Corps' projects. The computations will include analysis of rivers, lakes, reservoirs, aquifers, wells, diversions, and other inflow/outflow sources. Computer programs will be developed using state-of-the-art software engineering methods. Corps groundwater analysis needs and capabilities of the profession have been assessed through field survey, literature review, review of field projects, and participation on the Army Groundwater Modeling committee. Conceptual designs for connection of surface/groundwater models have been made. A surface reservoir package was developed for the USGS MODFLOW model; it was published as USGS Open File Report 96-364. A drawdown algorithm was developed for calculation of water levels in wells simulated by MODFLOW. A review of available continuous SW/GW models in profession was completed. In FY1999, algorithms for simulating the interaction of surface water flows from HMS with groundwater flows from MODFLOW were analyzed.

Accomplishments and Outlook

This work was suspended in FY2000 because of budget cuts.

New Work Units for FY2001

Flood Impact Analysis

The objective is to develop new flood impact analysis methods that will better enable the Corps to efficiently perform its flood damage and associated impact analysis responsibilities. The goal is to provide Corps field offices with a method that highly integrates existing capabilities with analysis and display enhancements to augment flood impact assessments and project formulation and evaluation capabilities. The analysis area may represent a watershed or a specific region wherein inventory of potential damage and associated impacts may be applied for flood damage reduction risk-based studies, water management event impact analyses, 404 permit assessments, etc. An enhanced and improved flood impact analysis methodology will be developed. It will include a variety of structure inventory methods (grid-cells of land use & census blocks, parcels, and unique structures), plan formulation and evaluation with risk-based analyses, and sequential-flood-event urban and agricultural impact analyses capabilities. Three types or levels of analyses are planned: traditional without spatial data; spatially referenced data and analyses with regard to stream stationing; and spatially referenced data and analyses with capabilities for users to interact with data processing (primarily inventories) and damage reduction evaluations (local protection, nonstructural, etc.). In FY2001, a design for the new Flood Impact methodology will be developed and enhanced risk-based and GIS interactive features will be developed.

Advanced Geospatial H&H Analysis

There is now the opportunity to build an advanced spatial data support structures into hydrologic engineering models for derivation of basin topology and hydrologic and hydraulic parameters. Digital elevation data will be the primary source of topographic information with which to develop spatially distributed models. Spatial precipitation will be based on both gaged data and radar-sensed distributions. New spatial data representations will be used in the Hydrologic Engineering Center's GeoHMS and GeoRAS utilities to estimate parameters for HEC-HMS and HEC-RAS. Spatially distributed hydrologic and hydraulic data will be obtained from GIS and DEM databases, including the National Hydrographic Data Base. That information will be interpreted and analyzed with spatial data processors (e.g., Arc/Info GIS system) to create the topology for and contents of hydrologic and hydraulic models. Use of high-resolution remote-sensing and digital terrain data and more sophisticated methods for terrain (elevation) analysis will be investigated with the goal of improving hydrologic parameter extraction from digital elevation models (DEMs) in flat terrain, or where non-contributing areas are present. In FY2001, expanded GIS and DTM methods for GeoHMS and GeoRAS will be released.

Environmental Quality Enhancements for Catchment Analysis

Guidance and tools are needed to assure effective integration of water quality and quality studies for Corps projects. This work unit will assess technology availability and needs for integrated water quantity and quality studies of the watershed. An array of tools and guidance for watershed investigations will be provided. This work will be closely coordinated with the work unit on ‘Integration of the Hydrologic Engineering Center’s NexGen Software for Watershed Studies’ and with EPA’s ‘BASINS’ work. The goal is to be able to use existing Corps hydrologic and hydraulic models and interface them with other state-of-the-art models for water quality. For instance, non-point source land surface runoff quality may be computed by EPA’s HSPF model using precipitation intensity and flow velocity estimates from HEC-HMS. This could be accomplished linking HMS results to HSPF. Work in FY2001 will report on existing technology and potential integration methods.

Reservoir System Flood Optimization

The many and complex interactions between water use and water control interests make reservoir water management decisions very difficult and time consuming. The short planning horizon available for flood control operations necessitates both initial, basin-wide analysis of flood operation in the long term and the ability to model imminent events comprehensively and quickly in the near term. The objective of this work unit is to develop and implement systems analysis and optimization techniques to efficiently analyze reservoir water decisions for flood management. The existing flood control optimization methodology within HEC-ResFloodOpt will be enhanced creating a more effective tool for developing and evaluating operating rules targeted at flood control. That methodology will be further enhanced to allow integrated use of probabilistic flood forecasts in short term flood operations. FY2001 proposed work will concentrate on implementing 'limited foresight,' refined penalties, and enhanced outlet analysis capabilities.

Risk Analysis of Water Resources Investments Research Program

FY2000 Work Unit

- Risk and Uncertainty of Hydrologic Engineering Analysis of Riverine Environmental Restoration Studies

New Work Unit for FY2001

- Residual Risk of Flood Damage Reduction Projects

FY2000 Work Units

Risk and Uncertainty of Hydrologic Engineering Analysis of Riverine Environmental Restoration Studies

The Corps studies and implements riverine environmental restoration projects to protect and enhance the nation's environment. Notable examples include the Upper Mississippi and Kissimmee Rivers restoration projects. Federal policy is that risk-based (risk and uncertainty) analyses be incorporated into the technical studies performed by water resources agencies. Riverine environmental restoration studies require the statistical uncertainty of key variables associated with low- and high-flow regimes affecting the design, maintenance, and operation of the project over its life be quantified and included in the analyses. Low-flow uncertainty variables may include long-term records, droughts and their persistence, water levels and depths, duration's, and seasonal variations. High flows are of interest primarily to assess maintenance requirements and cost and any induced flooding impacts. ER 1105-101 and EM 1110-2-1619 cover the uncertainty analysis requirements for high-flow analysis considerations. In FY1999, accomplishments included development of a basic hydrologic analysis framework; definition of hydrologic parameters important in restoration studies; examination of risk and uncertainty associated with these parameters; and initiation of field contact on hydrologic analysis being conducted in Corps restoration studies.

Accomplishments and Outlook

In FY2000, work began on documenting hydrologic analysis being conducted in Corps restoration studies. Several potential case studies were identified. A Hydrology/Hydraulics Guide Manual for Riverine Restoration Studies was drafted. A case study for the manual was begun. This work unit will conclude next FY with the completion of the case study and guide manual.

New Work Units for FY2001

Residual Risk of Flood Damage Reduction Projects

Flood damage reduction studies involve an integrated and complex analysis process designed to provide decision-makers with an array of information on viable alternatives. This process presently lacks sufficient procedures for explicitly defining the residual flood risk associated with various project types and site conditions when the designed operation is significantly impaired or the project capacity is exceeded. This work unit will create procedures and capabilities to define and communicate the residual flood risk for without-project conditions and with various project types and study settings. This will include: information on the flood characteristics resulting from impaired-operation for a range of events; development of project performance risk

indicators and information; and assessment of capacity exceedance events impacts on the physical study setting, general population, and the responsible response agencies. The methods must be performed within existing Corps engineering requirements and include such components as risk-based analysis approaches.

Accomplishments and Outlook

This was a new work unit in FY2000. Work concentrated on collecting spatially referenced data sets (on aerial photographs) representing flood inundation areas, velocities, and warning times. This information will be used as tests to assist in depicting the residual risk associated with forecasted, observed, or hypothetical events. This analysis and a report on the results will be completed next FY.

Geographic Information Systems Research Program

FY2000 Work Unit

- Flood Damage Analysis using GIS Technology

New Work Unit for FY2001

- DEM processing for Hydrology

Work Units for FY2000

Flood Damage Analysis using GIS Technology

Planning flood damage reduction projects requires an integrated participatory approach, the use of a variety of information and data sources, and analysis procedures and results that are easily interpreted by the participants and decision-makers. The variety of data and analyses required can easily bring about: duplication of efforts; increased field survey time and costs; complicated spatially distributed displays of results; and loss of information useful to other and future projects. GIS data capabilities together with an analytical software framework can provide flood damage analyses, and results displays to meet the needs of these complex flood damage reduction studies. Algorithms will be developed and integrated with the HEC-FDA computer program. The work will be coordinated with other Corps GIS activities such as those being developed under the Corps Water Management System by CECRL, and other Hydrologic Engineering Center's R&D work. In FY1998, this work unit began with detailed design of approaches for interfacing HEC-FDA with GIS capabilities. The design entailed an interrelational query between a digital terrain model, a digital water surface and a grid-cell or structure inventory. The design allows for aggregation of damages, defined by grids or individual structures, to an index location for predefined floods (stages). In FY1999, prototype grid-cell flood damage analysis methods and displays were completed. Algorithms for the beta grid-cell software were developed. A prototype of the GIS/image structure inventory analysis capabilities and HEC-FDA interfaces were also developed.

Accomplishments and Outlook

In FY2000, the initial version of HEC-FDA with grid-cell GIS capabilities was completed. Its release is pending changes for and integration with the newly revised Flood Damage Analysis Package. These products complete the work planned for this work unit.

New Work Units for FY2001

DEM Processing for Hydrology

Planning, engineering, and operations studies frequently use digital elevation data. Digital elevation models, DEMs, have been developed by the USGS and others to meet that need. Unfortunately, not all the DEMs have been developed with the same specifications. Oftentimes, several different data sets, including survey data in CADD or ASCII formats may cover the area of interest, and considerable processing is required to obtain a hydrologically-corrected data set to use for analysis. Finally, man-made features on the landscape sometimes prevent the downhill tracking algorithms from properly delineating the drainage network. This work unit develops tools and procedures to aid GIS users in improving DEMs for use in hydrologic modeling. The necessary functions include: 1) converting DEMs and other source data to a common projection, cell size, units, and horizontal and vertical datum; 2) mosaicking partial

coverages together or blending data from or separate sources; 3) re-sampling grids to the desired working projection; 4) automatically generating standardized metadata; 5) performing preliminary drainage analysis for a limited area to identify inadequacies of the elevation grid; and 6) developing simple grid editing tools to make corrections to any trouble spots thus identified.

Accomplishments and Outlook

In FY2000, requirements were developed and current DEM processing methods were assessed. Design specifications for new capabilities were developed. Some preliminary algorithms and procedures were also developed. In FY2001, case studies using the procedures will be undertaken and tools and guidance for DEM preprocessing released.

Risk Analysis for Dam Safety Research Program

FY2000 Work Units

- Assessing Hydrologic Loading Uncertainty
- Estimating Probability of Extreme Floods

Work Units for FY2000

Assessing Hydrologic Loading Uncertainty

This work focuses on quantifying uncertainty in the estimates of hydrologic variables to obtain the uncertainty in the estimates of extreme floods. Hydrologic variable candidates are extreme precipitation, watershed infiltration/interception, antecedent flood/moisture conditions, river routing, and antecedent reservoir levels. Event trees, numerical integration (Monte Carlo simulation) and other approaches in the risk analysis profession will be considered to derive the uncertainty in the extreme flood estimates given the likely estimates of the hydrologic variables. Methodologies, software, and guidance will be developed for use by Corps field offices. In FY1999, methods for estimating uncertainty in precipitation and floods were reviewed and a position paper drafted. A promising method for analysis and extrapolation of rainfall statistics and combination with runoff factors in a Monte Carlo simulation was identified. A contract was let (in conjunction with the next work unit) to perform a test application of this methodology on a case study; work began with analysis of precipitation statistics on the American River watershed near Sacramento, California.

Accomplishments and Outlook

In FY2000, work continued on the case study evaluation of the proposed methodology. Recommendations for a Corps-wide approach and software will be made in FY2001 to complete this work unit.

Estimating Probability of Extreme Floods

The extreme-flood probability analysis will focus on approaches recommended by the National Research Council and recent national and international efforts. In particular, recent work with respect to estimating the probability of extreme precipitation, paleoflood magnitudes, and impacts of climate change will be evaluated. Methods will be developed to extrapolate flood probabilities of historical floods to rare floods and extreme probable maximum events. The applicability of the methods in different geographic areas will also be evaluated, e.g., paleoflood evidence is not as prevalent in the eastern U.S. Methodologies, software, and guidance will be developed for use by Corps' field offices. In FY1999, a review of the state-of-the-art of methods for estimating the probability of extreme floods was made. The efforts concentrated on paleoflood methodologies and extreme precipitation estimation. A promising methodology for estimating and extrapolating extreme precipitation and computing runoff with a Monte Carlo simulation was identified and a case study begun (in conjunction with the above work unit) for a case study evaluation. Methods for paleoflood magnitude and frequency estimation were reviewed and a summary report written.

Accomplishments and Outlook

In FY2000, potential methods for use of paleoflood information in flood frequency analysis are being investigated via participation in a professional society committee for that purpose. In FY2000, the paleoflood information paper will be further developed and the feasibility of estimating the probability of extreme floods will be assessed. Recommendations for a Corps-wide approach and software will be made in FY2001 to complete this work unit.

CORPS WATER MANAGEMENT SYSTEM

The Corps Water Management System (CWMS) provides improved Automated Information System (AIS) support to enable the Corps to efficiently and effectively accomplish the water control management component of its Civil Works mission. This includes water management of the more than 700 dams and reservoir projects constructed by the Corps. The CWMS will:

a) acquire project status and hydromet data in real-time;
b) store, manage, and report hydromet and project data, documents, imagery, and other data;
c) model, forecast, and simulate reservoir and river status; and
d) perform decision support analysis and information dissemination.

The CWMS project includes replacement of pre-1990 computer and related hardware; upgrades to field instrumentation and communications equipment; and upgrades of existing Water Control Data System (WCDS) software, including porting existing products, modifying and upgrading existing products, and development of new software products. The Hydrologic Engineering Center is responsible for development of new Corps-wide software for the CWMS. Subsequent sections describe the associated software activities. Major efforts have been completed that include development of system requirements, and the conceptual design of system components. For FY2001, CWMS test Version 3.0 will be completed, and a favorable Milestone Decision III secured to deploy CWMS Version 1.0. Deployment will commence in the summer of calendar year 2001 and continue through December 2002. Critical decisions to be made in FY2001 include: deployment schedule and sequence; maintenance and betterments funding; and deployment geo-configuration.

The CWMS project is making extensive use of products developed under the Hydrologic Engineering R&D program. In several instances, noted in the following descriptive information, joint R&D and CWMS funding is supporting product development and integration into CWMS.

- Data Capture
- Data Decoding, Transformation, and Validation
- Data Base System
- Flow Forecasting, Forecast Evaluation
- Reservoir Evaluation System
- River Hydraulics, Stage Forecasting
- Flood Impact Analysis
- System Integration, Implementation, and Management
- Application of GIS and Image Technology
- Control and Visualization Interface
- Field Application Assistance

Data Capture

This task provides water control sites connectivity to required data sources. Candidate sites include; NWS-AWIPS (NEXRAD products), NWS-AFOS, GOES/DOMSAT, land-based radio, ALERT receive sites, and cooperating agency networks.

Accomplishments and Outlook

This data capture software consists of three primary components: StreamSender, DCWriter, and DCReader. Test Version 2 of these software products have been moved to the four field test sites and are actively being tested for proper operation and robustness. Design of the StreamSender program allows for multiple client connections from DCWriter programs at various locations on the wide-area network.

Future activities include providing the capability to capture gridded precipitation products such as the 6-hour and 24-hour Quantitative Precipitation Forecast (QPF) and NEXRAD Stage III precipitation products available from the National Weather Service (NWS). These products will likely be received from a DOMSAT or NOAA port downlink, or a local connection to the NWS. As Gridded precipitation products are received, they will be loaded as records into a DSS file. The data will be stored using the Standard Hydrologic Grid (SHG) coordinate system and be made available to the modeling components of CWMS.

Other activities planned for future releases of the software include revision of the mechanisms, which operate the StreamSender and DCWriter programs. Currently the two programs interact with each other using a single communication channel for both program control and data flow. This will be upgraded to two channels, so that control information will be passed on one channel and data passed on the second channel. This should improve both the responsiveness and robustness of both programs.

Data Decoding, Transformation, and Validation

Current data streams being processed are for GOES, SHEF, QPF, and Stage III encoded products. The tasks involved are decoding software for QPF and Stage III gridded data, graphical user interface for interactive final validation of SHEF and GOES data and comprehensive real time data validation/transformation.

Accomplishments and Outlook

Field Test Version 2.0 of the CWMS data capture, decoding, transformation and validation is functional and being tested at each of the four field test sites. Implementation of the comprehensive transformation and validation components of the CWMS work is currently based on existing WCDS capabilities. These procedures reprocess a full set of data in time and space, regardless of the actual data received. In FY2001, testing will continue and the comprehensive data transformation and validation will selectively operate only on data received in a preceding, defined time period. The graphical user interface for the interactive validation of data will be tested under Version 3.0 of the CWMS.

Data Base System

Development of data base technology will eventually supply information of a wide variety, such as: hydrologic data, meteorological data, water quality data, project descriptions and design parameters, manuals, reports, project documents, geographic information, spatial data displays, maps, satellite images, and ultimately sound and video. This will provide the means and standards to have a common nomenclature and structure to data bases located in all Corps of Engineers CWMS computer systems.

Accomplishments and Outlook

Within the context of a CWMS Test Version 2.0 Software System, the Data Base Interface (DBI) application was designed, developed, and demonstrated to add enhanced data management capability and improved performance. Other CWMS components access and store data by passing data objects to the DBI for storage and retrieval from the Oracle relational data base management system (RDBMS). The enhancements to the DBI data management capability included several CWMS software components to manage data quality, time zones, and data derivation. The enhancements to the DBI performance improved functional capability within DBI server to move data between the CWMS Oracle database and modeling, transformation, validation working DSS files.

The Field Test Version 2.0 data base subsystem (DBI and Oracle) are being used in the four field test sites to manage time-series data and location information as they appropriately move between CWMS applications and the CWMS Oracle database as specified for Version 2.0 requirements. In FY2001, Test Version 3.0 is being developed to add capabilities in the DBI and Oracle to manage paired-data information such a rating tables. Another addition in Test Version 3.0 is an enhanced GUI for editing descriptive location data, time series descriptive and value data, and paired-data descriptive and value data stored in the CWMS Oracle database.

Flow Forecasting, Forecast Evaluation

Hydrologic forecast models are designed for effective and efficient runoff forecasting for a broad range of storm-runoff and low-flow conditions. The structure of the forecast model allows for incorporation of spatially distributed inputs (spatial precipitation) and parameters. The input and data-handling structures of models enable convenient specification and centralized interfaces to the model database. The model will permit parameter-state updating based on real-time feedback. In addition, the model is be coupled with hydraulic, reservoir system, and damage analysis models. The forecast software utilizes components of the Hydrologic Modeling System (HEC-HMS), which is being developed under the Catchment Analysis System work unit of the Hydrologic Engineering R&D program.

Accomplishments and Outlook

Visualization of precipitation grids within CWMS was greatly improved by the development of gridUtil and the incorporation of gridUtil's display functions within the CAVI. Design of improvements in the Meteorological Forecast Processor (MFP) and the Hydrologic Forecast Processor (HFP) was begun. Improved features include the ability to use Quantitative Precipitation Forecast (QPF) values in MFP, improved forecast summaries and controls for parameter optimization in HFP. FY2001 work efforts will include completion of these design efforts and their implementation in CWMS Test Version 3 and the release product.

As resources permit, a number of enhancements to the flow forecasting component of CWMS are planned. These include the use of saved states in HMS to allow long-term modeling for forecasts, greater user control over interpolation of gage precipitation or calibration of radar-observed precipitation, development of tools to incorporate snow-melt into forecasts in real time, and incorporation of additional baseflow, loss, and runoff methods into CWMS.

Reservoir Evaluation System

The purpose of this work is to incorporate a family of reservoir tools into the CWMS. This capability is intended to meet the needs of the water manager to make reservoir release decision for complex systems of multi-purpose reservoirs. The reservoir analysis tools for flood and complex low-flow conditions are to be developed under the Hydrologic Engineering R&D program, Reservoir Analysis System Work Unit.

Accomplishments and Outlook

During FY2000, the Test Version 2.0 HEC-ResSim activities included extending the operation criteria to allow a reservoir to operate for any number of downstream conditions as well as for itself. Reservoir Zone definition and enhanced operation rules were also added. Functional developments targeted for completion in FY2001 include multiple reservoirs operating as one system, multiple controllable outlets per reservoir, gate regulation operation, and enhanced output control. The next level of operations will include hydropower generation and individual gate operation.

River Hydraulics, Stage Forecasting

The modeling of river hydraulics for stage forecasting includes both steady state and unsteady modeling. A Hydrologic Engineering R&D work unit is developing the River Analysis System (HEC-RAS) computer program to provide steady, unsteady and sediment transport functions. The objective of this task is to incorporate HEC-RAS within the water control system to provide steady and unsteady flow modeling.

Accomplishments and Outlook

Field test Version 2.0 was tested in each of the four field test sites. These tests utilize the steady state capabilities of the HEC-RAS program. Test Version 3.0 will implement unsteady flow computation capability. The GUI that is available for the CAVI allows specific model parameters to be varied for evaluation alternative hydraulic conditions. In FY2001 unsteady flow HEC-RAS capabilities will be finalized in preparation for deploying CWMS Version 1.0 beginning in the summer.

Flood Impact Analysis

The Hydrologic Engineering Center's Flood Impact Analysis (HEC-FIA) computer program is designed to be fully integrated with the CWMS, with capabilities to: 1) provide ready assessment of flood impacts for forecasted and/or observed events, and 2) post flood assessments of Corps project benefit accomplishments. Analyses are performed by impact areas that include computing urban damage flood by categories, agricultural damage by crops, number of structures flooded by categories, area flooded, and population impacted. The seasonal variation in potential, crop damage and effects of previous events are considered in the analyses. Results are displayed by impact areas, Corps Districts, states, Congressional Districts, counties, communities, and flood districts. Access to control and results visualization, are via the Control and Visualization Interface (CAVI) through its graphical representation of the watershed and river system.

Accomplishments and Outlook

In FY2000, Field Test Version 2.0 of the program has been undergoing testing. Revisions to the Version 1.0 user's manual continue to be made to reflect Field Test Version 2.0 and 3.0 capabilities. The data has been tested on a variety of basins at the field test sites. Work in FY2000 will focus on enhancing the GIS capabilities and links and provisions of added output results, warnings, and help messages.

System Integration, Implementation, and Management

This task provides standards for the development of components that will integrate with each other through database and control interfaces. Included are: a common scripting language across all products that will control execution; generalized messaging capability to permit processes to communicate with each other during their execution; libraries of shared functionality for use by multiple components; a programming environment that will provide

flexibility in delivery of communication, database, modeling and graphic products in a changing hardware/software marketplace.

Accomplishments and Outlook

In FY2000, Field Test Version 2.0 was implemented and tested at the four-field site has verified the flexibility of the underlying software architecture. The scripting language was installed in the major CWMS components. The efficiency of network components were examined in Local and Wide Area Network setups (LAN and WAN), and improvements made to the code for these situations.

In FY2001 the messaging system will be made active. The alarm system will be implemented to provide active notification of data flow or other system anomalies.

Application of GIS and Image Technology

This work focuses on the unique capabilities that GIS can provide in improving to water-control decision making and operations, and hydraulic and hydrologic analysis. These objectives can be broken down into four areas: 1) visualization of GIS data, 2) integration of GIS and CWMS databases, 3) interpretation of remotely sensed images, and 4) implementation of RS/GIS tools.

Accomplishments and Outlook

In FY2000, the chief accomplishments in the areas of GIS and remote sensing were improved integration of GIS data into the modeling components of CWMS. Tools developed both within and outside of the CWMS project can now be used to develop hydrologic, hydraulic, and flood impact analysis models to be included in CWMS. This level of integration has brought with it a greater awareness of Corps geospatial data standards, and an important contribution to the FY2001 effort will be a document detailing how geospatial data should be prepared to meet the needs of CWMS and other Corps operations at the same time. Performance of GIS tools remains a concern and enhancements to CWMS may include shifting of more GIS activities to client-side machines to avoid network performance bottlenecks

Control and Visualization Interface

The Control and Visualization Interface (CAVI), oversees and controls the operation of the functional modules. It includes mechanisms for facilitating parameter adjustments, spatial and temporal visualization of observed and forecasted information, operation control of the modeling system, and an evaluation capability of pertinent information. The CAVI provides access to both, the current, observed states of the water system and the results from different forecast scenarios. Observed and forecasted information is displayed graphically, both in traditional two-dimensional plots, and in spatial graphics, using schematic, map or photographic/image backgrounds.

Accomplishments and Outlook

In FY2000, the CAVI was extended with improved model graphics, and the data acquisition and data visualization modules were implemented. The data acquisition module provides a graphical view of the state of all of the data acquisition processes, including data arrival times and data screening and quality information. The data visualization module gives an overview of observed data in the watershed. Information in these modules is conveyed using “thumbnail plot icons,” “quality color bar icons,” and “threshold color bar icons,” as well as through plot and tabulation screens. Gridded precipitation information, from either NexRad radar or the interpolation of data from gages, is displayed as a background view and may be animated over time in the observed data module.

In FY2001, the modeling capabilities in the CAVI will be enhanced to improve the access and execution of models, as well as enhancement of the display of modeling results. Users will be able to group icons and map background together in "layers", and display only those layers that they feel are pertinent. Security features will be added, as well as interfaces to the CWMS messaging system.

Field Application Assistance

This provides field offices with assistance during the testing phase of the CWMS project. This task is further intended to provide assistance with hardware/system software advice. Assistance takes the form of implementation of software components at the four selected Corps test locations.

Accomplishments and Outlook

In FY2000, primary assistance was provided to the Baltimore District, Huntington District, Omaha District, and the NorthWestern Division. Each of the field test sites implemented the CWMS Test Version 2.0 software on their local systems. Support is furnished to WCDS field sites for each of the existing software products.

In FY2001, the focus will be on implementation of Test Version 3.0 at the same four sites. In particular the testing of the client-server architecture across the CEAP wide area network is of most significant concern.

TRAINING AND TECHNOLOGY TRANSFER

The training activities of the Hydrologic Engineering Center are designed to increase the technical capabilities of the Corps field offices to meet needs and solve problems in hydrologic engineering and water resource planning. The training provides instruction in technical concepts and methods, and assists field offices in applying the methods to complex water resource problems and studies. This technology transfer is carried out through a variety of training courses and working sessions, with the emphasis on practical applications, using appropriate technology to solve real-world problems.

Training Programs

The Hydrologic Engineering Center's training and technology transfer activities include the following:

- Training Courses
- Workshops
- Seminars
- Professional Development Assignments
- Videotaped Lectures
- Technical Publications
- The Hydrologic Engineering Center's Homepage: www.hec.usace.army.mil
- State-of-the-Art Software and Associated Support

Training Courses

Six courses were conducted under the Proponent Sponsored Engineers Corps Training (PROSPECT) Program. The Hydrologic Engineering Center's courses presented in FY2000 and planned for FY2001 are shown in the following tables. Courses are usually one week in duration, and include formal lectures and practical problem-solving workshop sessions. Guest instructors from the Corps offices, universities and private industry are invited to participate. These instructors supplement the capabilities of the Center's staff.

FY2000

Course Title	Date	Length (weeks)	No. of Students
Advanced HEC-RAS	24-28 Jan 2000	1	27
H&H Applications for GIS	13-17 Mar 2000	1	30
Flood Hydrology with HEC-HMS	08-12 Nay 2000	1	31
Reservoir System Analysis	19-23 Jun 2000	1	19
Water and the Watershed	17-21 Jul 2000	1	28
Hydrologic Analysis of Wetlands/Restoration	11-15 Sep 2000	1	27
	TOTALS:	6	162

FY2001

Course Title	Date	Length (weeks)
Flood Frequency Analysis	23-27 Oct 2000	1
Basic HEC-RAS	13-17 Nov 2000	1
GIS for Hydrologic Engineering	04-08 Dec 2000	1
Basic HEC-HMS	22-26 Jan 2001	1
Hydrologic Eng for Planning	05-09 Feb 2001	1
Flood Damage Analysis with GIS	12-16 Mar 2001	1
Unsteady Flow – HEC-RAS	02-06 Apr 2001	1
Water and the Watershed	07-11 May 2001	1
Advanced HEC-HMS	20-24 Aug 2001	1
River & Wetlands Restoration	10-14 Sep 2001	1
	TOTALS:	10

Workshops

Workshops are conducted each year, on a reimbursable basis, at the request of individual district or division offices. The workshop may be similar in content to one of the regular courses, or it may focus on a particular need for which training is not available elsewhere. The duration of these workshops range from one day to one week. They are usually held at the requestor's office to allow greater participation by Corps office staff, as well as local, state and other federal agencies. During FY2000, the Hydrologic Engineering Center conducted four workshops for a total of 14 days of training and 98 students.

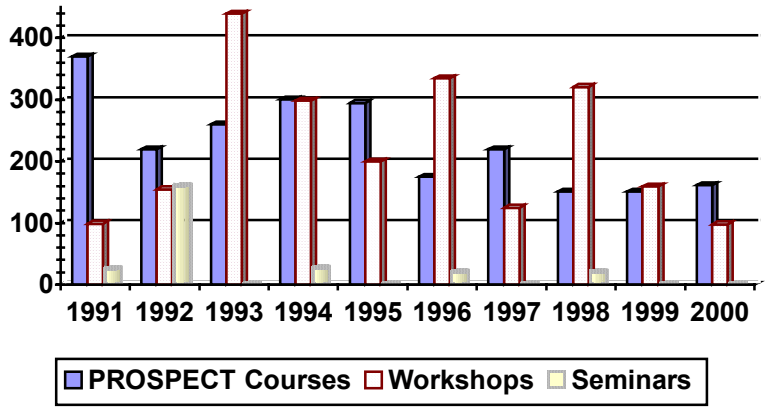
Seminars

Seminars provide a forum to discuss field problems and potential solutions, and to identify the need for new techniques. There were no seminars during FY2000.

Training Summary

A ten-year summary of attendance in courses, workshops, and seminars is shown in the chart below. The interest in courses is on the upswing, likely reflecting new additions to the Corps workforce.

Student Attendance Record
PROSPECT Courses, Workshops and Seminars



Professional Development Assignments

The Hydrologic Engineering Center initiated a formal Professional Development Program in FY1992. The program provides broad training and work experience to candidates interested in hydrologic engineering and planning analysis methodologies. It provides an opportunity to participate in challenging studies in the Research, Technical Assistance, Training, and Planning Analysis Divisions. Selected candidates will investigate new techniques, which, in many instances, have received only limited field application. Primary areas of interest include: watershed hydrology, river hydraulics, reservoir system analysis, statistical methods, and water resources planning studies involving risk and uncertainty, flood damage and plan formulation, and water management.

Videotaped Lectures

Since 1974, the Hydrologic Engineering Center has made video tapes of selected training course lectures. The tapes are intended to supplement the training program by providing the course material to those unable to attend courses. These tapes are available as recorded to Corps offices on request. Copies are available to all others for the cost of duplicating and mailing the tapes. Approximately 350 tapes are available, and the annual distribution varies from 100 to 400 tapes.

Technical Publications

The Hydrologic Engineering Center focuses a substantial portion of its resources on the development and documentation of application software. Documentation includes computer program documents (user's manuals for the software), training documents, technical papers, research documents, project reports, and seminar proceedings. Many are placed on our web site; thousands of copies of documents were downloaded this past year. New and revised documentation issued during FY2000 are listed below.

A catalog of publications is available on request, and is posted on our web page. The Hydrologic Engineering Center provides publications to Corps offices and places most publications into the National Technical Information Service (NTIS) system for general distribution. NTIS reference numbers are listed in the Hydrologic Engineering Center's Publications Catalog. Their address is: National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; telephone (800) 553-6847, FAX (703) 605-6900. Additionally, the Hydrologic Engineering Center is placing computer program documentation and other documents on the Hydrologic Engineering Center's web site.

- Computer Program Documents
  - CPD-31, Interior Flood Hydrograph package, User's Manual, Sep 90, 443 pp.
  - CPD-74A, Hydrologic Modeling System HEC-HMS, User's Manual, March 2000, 186 pp.
  - CPD-74B, Hydrologic Modeling System HEC-HMS, Technical Reference Manual, March 2000, 155 pp.
  - CPD-75, HEC-GeoRas, An extension for support of HEC-RAS using ArcView, User's Manual, April 2000, 93 pp.

- Technical Papers
  - TP-158, Corps Water Management System (CWMS), June 2000, 12 pp.
  - TP-159, Some History and Hydrology of the Panama Canal, June 2000, 8 pp.

Hydrologic Engineering Center Homepage

The Hydrologic Engineering Center has developed a World Wide Web homepage www.hec.usace.army.mil to provide information and a retrieval source for major computer programs and documents. Information is provided under six categories: Organization, Visitor Information, Training Program, Publications, Software and What's New. Current copies of our Newsletter, Catalogs, and Annual Report are available to all from this site. Corps offices may also keep up with the Hydrologic Engineering Center's activities documented in our Quarterly Reports. The NexGen computer programs and documents are made available as they are released. Also, some of the earlier programs have been made available. Example usage for June 1999 shows an average of 4,093 file transfers per day. Daily requests range from 1,329 to 6,361. The majority of these requests were from the USA; however foreign requests came from 56 countries, with over 1,000 requests coming from Australia, Canada, Germany, Spain, and Italy.

Computer Software and Support

The Hydrologic Engineering Center has been developing computer programs for hydrologic engineering and planning analysis procedures since its inception in 1964. Software has evolved from computerized procedures to complex modeling systems. The software runs on PC-DOS compatible computers, UNIX workstations and Windows PC's. Executable PC programs are made available to non-Corps's offices through NTIS and a network of program vendors.

For the older PC-DOS programs, the Hydrologic Engineering Center has developed a package concept that provides more convenient application of batch processing programs. A menu provides for naming necessary program files, creating and editing input data with the COED software, running application program(s), and reviewing output with the LIST software. Once the files have been defined, the various programs can be executed directly from the menu. Additionally, COED can provide on-screen displays of program input requirements for each batch program. These on-screen displays are based on the input description provided in the associated user's manuals. These packages are soon to be phased out as the NexGen software gains the larger user base.

The new programs, like HEC-RAS, HEC-HMS, and HEC-FDA are being developed for windows-based engineering workstations. HEC-RAS is a one-dimensional river hydraulics package that succeeds HEC-2. The Hydrologic Modeling System (HEC-HMS) is a watershed model that succeeds HEC-1, and the Flood Damage Analysis package succeeds the earlier multi-program package and includes risk and uncertainty in the analysis. At this time, HEC-RAS Version 2.2, HEC-HMS Version 1.1 and HEC-FDA Version 1.0 have been released.

Software Library

The following is a list of the primary software, by technical subject. Brief descriptions and computer hardware/software requirements for the programs are contained in the Computer Program catalog, which is available upon request, or on our homepage.

Numerical Model Area	Primary Software
Hydrology	HEC-HMS, HEC-1, HEC-GeoHMS, HEC-IFH
River Hydraulics	HEC-RAS, HEC-2, UNET and HEC-6, HEC-GeoRAS
Analytical Planning	HEC-FDA, HEC-FIA
Statistical Methods	HEC-4, HEC-FFA, and STATS
Reservoir Systems	HEC-5/5Q, HEC-ResSim, HEC-ResFloodOpt and HEC-ResPrm
Data Management	HEC-DSS, DSPLAY and DSSUTL
Water Control	CWMS

TECHNICAL ASSISTANCE PROJECTS

The Hydrologic Engineering Center's technical assistance program provides assistance and guidance to requesting Corps offices in the application of hydrologic engineering and water resources planning analysis techniques. Technical assistance activities are conducted on a cooperative and reimbursable basis. These activities enable HEC staff to maintain close contact with Corps personnel in district and division offices and to evaluate the effectiveness of new technology in a project application mode.

Each HEC division assists Corps offices in technical studies. The assistance varies from brief reviews of work done by others, functioning in an advisory role during the conduct of a study, to complex applications modeling involving a team of HEC and field office staff.

FY2000 Accomplishments

FY2000 technical assistance was $2,353,000. Assistance was provided to 14 Corps field offices, as well as, Headquarters (CECW), University of California, Davis (UCD), State of California and Metropolitan Water District of Southern California, Panama Canal Commission, and the National Institution for Building Sciences (NIBS).

Surface Water Hydrology

The Hydrologic Engineering Center's surface water hydrology technical assistance during the fiscal year covers a variety of topics. These include: arranging and participating in the Corps Hydrology Committee-sponsored seminar and meeting; flood warning-preparedness program assistance; snow and PMF studies; and assistance on several studies involving the new HEC-HMS applications. Also, new applications of geographic and terrain data were made for support of hydrologic modeling.

CECW	Headquarters: Civil Works Committee on Hydrology
CENAB	Baltimore District: Anacostia Basin Model Evaluation
CELRN	Nashville District: GIS HEC-HMS for Cumberland River
CEMVP	St. Paul District: Devils Lake Stochastic Hydrology
CENWS	Seattle District: Green and Puyallup Rivers Modeling
CESAM	Mobile District: Flood Warning-Preparedness Program Assistance
CESPK	Sacramento District: Sacramento/San Joaquin Comprehensive Basin HEC-HMS Study; Spillway Adequacy, Isabella Lake Project
CESPL	Los Angeles District: Las Vegas Wash Stream Restoration
CENWO	HEC-HMS Model for Ft. Carson, Colorado

Groundwater Hydrology

The Hydrologic Engineering Center continued its assistance to the Sacramento District in analyzing and modeling the Tooele Army Depot's pump-and-treat groundwater cleanup system. Also for SPK, modeling advice was provided for the Motorola clean up site.

Water Management

Assistance and consultation was provided HQUSACE in support of the Water Management mission. This included transferring the HQ Sun Solaris system to HEC, improving the stream gage management software, and support for the H&H Water Control/Quality web site now housed at HEC.

CESPK	Sacramento District: CWMS Transition Support
CEMVD	Mississippi Valley Division: CWMS Transition Support
CESWD	Southwestern Division: CWMS Communications Assistance
HQUSACE	Headquarters: CWMS Management Support; Gage Program Improvement

Reservoir Systems

The significant projects involving reservoirs included for the Sacramento District, beginning to port HEC-5 model data sets to the new HEC-ResSim model for the Sacramento - San Joaquin, California Comprehensive Study; applying the HEC-ResFloodOpt model to a problem of valuing incidental storage to flood reduction; and for the Rock Island District, analyzing a reservoir system on a major tributary to the Mississippi.

CENCR	Rock Island District: Iowa River Basin Reservoir Operations
CESPK	Sacramento District: Sacramento and San Joaquin Basins Comprehensive Study, and Valuation of Incidental Storage.
CENWD	Cumberland River Hydropower Evaluation with HEC-5.

River Hydraulics

An integrated HEC-RAS, inundation mapping, and flood damage computation system is being developed for a portion of the Susquehanna River for the North Atlantic Division and an updated HEC-2 model for the Rio Grande was reviewed for the Galveston District/International Boundary Commission. The largest effort was supporting the development of the Mississippi Basin Modeling System (UNET unsteady flow model) on behalf of HQUSACE.

CECW	Headquarters: Flood Plain Management Services (CEFPMS). Workshops, model documentation updates.
CESWG	Galveston District: HEC-2 model review for the District/IBC.
CESPK	Sacramento District: Update of HEC-RAS floodplain model to incorporate new data, UNET modeling support.
CECW	Headquarters: Mississippi River Basin UNET Modeling. HEC continued to provide support for the implementation of the UNET models for river operations. Assistance was provided in obtaining, analyzing, and using new digital terrain data for cross-section, river, and floodplain geometry.
CENAD	Susquehanna Flood Forecast/Impact Model Implementation
CESPL	Las Vegas Wash Habitat Restoration Study Assistance

Flood Damage

The Hydrologic Engineering Center is assisting the Sacramento and Rock Island districts in preparing HEC-FIA models of the Sacramento and San Joaquin basins, and Iowa and Des Moines river systems, respectively - an ongoing effort. Another flood damage analysis assistance project includes the applications of HEC-FDA to the Anacostia Rivers floodplains.

CESPK	Sacramento District: Sacramento and San Joaquin Phase I and II Comprehensive Study HEC-FIA Modeling
CEMVR	Iowa and Des Moines Rivers HEC-FIA modeling assistance
CENAB	Anacostia River HEC-FDA modeling
NIBS	Assistance to National Institute for Building Sciences/FEMA for development of flood loss component of HAZUS model
CENAD	Susquehanna Flood Forecast/Impact Damage Model Implementation

Statistics

The major review of the Upper Mississippi River System flood frequency relationships continues for the Rock Island District. The Hydrologic Engineering Center is the technical methods advisor for the study, and serves as liaison to the public involvement group. Several flood frequency studies were reviewed, including providing technical analyses and support to the Sacramento District in the review of the continuing studies of American River Flood Frequency.

CEMVR	Rock Island District: Upper Mississippi System Flood Frequency, Des Moines River Regulated Flood Frequency
CESPK	Sacramento District: American River Flood Frequencies, American River/Friant Dam Regulated Frequency Curve Review

Software Development Assistance

Improvements to HEC-FIA were sponsored by Sacramento District, and development began on a general GIS-based ecosystem evaluation model, also sponsored by Sacramento. Software is being written to assist in the Upper Mississippi frequency study for Rock Island District.

CESPK	Sacramento District: HEC-FIA improvements, E(Ecosystem)FM development
CEMVK	Vicksburg, District: Develop data translation program to import survey data into HEC-RAS
UCD	University of California, Davis: Enhancements to HEC-PRM (system optimization) for CalFed Study, Delta Simulation Model
CEMVR	Rock Island District: Frequency analysis software development